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The

Embryology

— of —

Crepidula

— by —

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Preliminary Note on the Embryology of Crepidula fornicata and of Urosalpinx cinerea. By E. G. CONKLIN.

Crepidula fornicata.

The time and manner in which Crepidula lays its eggs has been described by Dr. McMurrich.[1]

The cleavage follows the type found in Fusus, Planorbis, Neritina, etc. The first furrow is, with regard to the future embryo, a median longitudinal one, and divides the ovum into exactly equal right and left halves. (The method of determining the relation of the first furrow to the embryo cannot be explained without several figures). The second furrow is at right angles to the first and transverse to the long axis of the embryo, and it divides the egg into four equal macromeres. Of these, two meet in the centre in a line which Rabl[2] has called the "cross furrow;" the other two are acute toward the centre and do not meet each other. By the position of the macromeres with regard to the "cross furrow," the first and second cleavage furrows may easily be distinguished, *e.g.*, if the egg be viewed from the formative pole and so that one of the cleavage furrows is in the line of vision, the macromere to the right of this furrow and farthest from the observer will be acute at its centre if the furrow in the line of vision be the second cleavage furrow; it will be obtuse, *i.e.*, will meet the opposite macromeres in the "cross furrow" if the furrow in the line of vision be the first cleavage furrow. Of course the reverse would hold true if the egg were viewed from the vegetative pole. The examination of many hundreds of eggs has shown that the position of the macromeres in relation to the "cross furrow" and to the first and second cleavage planes is a constant one, and that the first and second furrows may always be distinguished in the way mentioned. The macromeres as distinguished from the micromeres do not again divide until late in the course of segmentation, and as they do not change their relative position it becomes very easy to orient all the future furrows and cells with reference to the first two furrows. The polar bodies which are at the centre of the ectodermal area also mark the centre of the dorsal surface of the embryo, while the blastopore closes and the definitive mouth appears almost directly opposite them. Until after the formation of the blastopore the chief axis is the one drawn from the centre of the ectodermal to the centre of the endodermal area; with regard to this axis the egg is for some time radially symmetrical; the chief axis of the embryo (the antero-posterior) is at right angles to the chief axis of the egg. At an early period there is a trace of a segmentation cavity, which however is soon obliterated. The formation of micromeres proceeds with wonderful regularity, following the law formulated by Rabl,[3] new micromeres always being formed in fours either by being cut off from the four macromeres or by the division of four micromeres already formed. When twenty-four micromeres have been formed one of the macromeres, which later developments show to be on the posterior side of the ovum and to the left of the median line, divides into a larger ventral and a smaller dorsal moiety. The smaller cell, which, unlike the ectoderm cells, contains yolk, moves to the right until it comes to lie at the posterior end of the median furrow between the two posterior macromeres; it very soon divides into a right and a left half, and at a later stage these two cells give rise to two mesoblastic bands which extend forward over the right and left sides of the dorsal surface.

Save for these mesoblasts the radial symmetry at the stage with thirty-six micromeres is perfect. At this stage twelve of the micromeres

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1 A contribution to the Embryology of the Marine Prosobranchs. Studies from Biol. Lab., J. H. U., Vol. 3.

2 Carl Rabl, Ueber die Entwicklung der Tellerschnecke. Morph. Jahrbuch, Bd. 5.

3 *Loc. cit.*

form a cross with three cells in each arm, the crossing of the arms being exactly at the centre of the ectodermal area. Two of the arms lie in the antero posterior axis, two in the transverse axis; one arm is anterior, one posterior, one right and one left. In the next stage the radial symmetry is no longer perfect, since three arms of the cross lengthen so as to contain four cells each, while the posterior arm does not lengthen until later. However, with this exception, the radial symmetry is preserved until fifty-two micromeres are formed; at this stage the posterior arm lengthens by one cell and the three other arms split longitudinally. At the same time each of the macromeres, except the one mentioned above as giving rise to the mesoblast, divides as did the later into a larger and a smaller moiety. The three smaller cells take positions on the periphery of the egg in the furrows separating the macromeres, one at each end of the transverse furrow and one at the anterior end of the longitudinal furrow.

In normal eggs there is not a trace of an invagination at the ectodermal pole, such as has been described for Neritina and Fulga, though eggs which were developing abnormally often showed such an invagination together with other irregularities, *e. g.*, the spreading apart of the macromeres and the formation of large yolk containing cells at the periphery of the ectodermal area instead of the small protoplasmic ectoderm cells which are usually formed.

The gastrula is formed by typical epibole. On all sides the ectoderm cells grow around toward the ventral side at an equal rate; thus the blastopore is formed in the middle of the ventral side. The mesoblasts are carried around with the ectoderm to the ventral side, where they lie at the posterior edge of the blastopore. The mesoblastic bands are soon separated from the mesoblasts; the latter continue to proliferate mesoderm, which extends forward in the lips of the blastopore.

The cross above mentioned resembles very much an arrangement of cells figured by Blochmann[1] for Neritina, the terminal cells in the transverse arms of which are called by him velar cells. In Crepidula it seems that no part of the transverse arms forms the velum. However, the cells of the posterior arm grow very large, the nuclei are vesicular and stain lightly, and the cells become covered by fine cilia, which protrude through a thin cuticula; though at first these ciliated cells lie wholly on the posterior side of the ovum, they move forward in the course of development until they come to lie on the anterior side, and as they increase enormously in size, though they seldom divide, it comes about that they cover the anterior part of the dorsal area, extend around over the anterior end of the embryo and down over its sides. These cells finally form the walls of a large head vesicle.

The velum appears first on the ventral side, just anterior to the mouth, and consists at first of a *single* row of cells. Later it is composed of several rows, some of which are adoral, and at least a single row runs posterior to the mouth. It is not completed dorsally until much later, though soon after the definitive mouth is formed the velum splits on each side of the embryo, and about half way between the ventral and dorsal surfaces, into an anterior and posterior branch; the later continues up over the dorsal surface just posterior to the large ciliated cells; the anterior branch, which is the chief one, turns forward over the sides of the head vesicle, and quite late in development the two arms of the anterior branch meet and fuse on the mid line just in front of the ventral part of the preoral velum. Thus two large velar lobes are formed, one on each side. The posterior branch of the velum appears to be the postoral ciliated band, the anterior branch the preoral; from the corners of the mouth to the middle of the sides of the embryo the two are fused, while ventrally they are separated by the mouth and dorsally by the whole diameter of the head vesicle. A postoral band of cilia has been described as present in the veligers of several gastropods, and among these Crepidula,[2] but I am not aware that any one has hitherto

[1] F. Blochmann, Ueber die Entwicklung der *Neritina fluviatilis*. Zeit. wiss. Zool., Bd. 36.

[2] McMurrich. J. H. U. Circulars, No. 44, 1885.

found the two separated dorsally. The velum does not become ciliated until quite late in development, though the embryo swims about in the pouch by means of the cilia of the large ciliated cells which form the head vesicle.

The shell gland appears on the dorsal surface immediately posterior to the second or transverse furrow as a prominence of ectoderm cells. In the place of this prominence an invagination afterward appears; the margin of the invagination extends rapidly and a thin cuticle, the first indication of the shell, is secreted by the invaginated cells. As development proceeds the shell becomes asymmetrical, developing more rapidly on the left side than on the right.

The foot arises as a *single* median protuberance just posterior to the mouth. While it shows no trace of a double origin, it occupies a region along which the blastopore closed, so that really the foot may be considered as having arisen on both sides of the blastopore, though the lips of the latter have fused before the former appears. Running from the mouth backward over the median surface of the foot is a row of large ciliated cells resembling those on the dorsal area.

At the posterior end of the embryo three or four large ciliated anal cells appear, and just ventral to these the distal end of the intestine is pressed against the ectoderm. The proctodeal invagination does not occur until late in development. The intestine is a tube with a distinct lumen, its walls being formed of small cells free from yolk. In the course of development its central end, where it opens into the cavity between the yolk spheres is carried anteriorly and to the right. Throughout its whole length the intestine is pressed closely against the ectoderm.

The supra-oesophageal ganglia appear as proliferation of the ectoderm on each side of and dorsal to the mouth; the eyes are formed in connection with these ganglia as involutions of ectoderm. The ganglia of the two sides are connected by a commissure, and from the centre of the latter a nerve runs forward to the centre of the apical plate, where there is a ciliated depression in the ectoderm, which I believe is a sense organ. A commissure connects the supra-oesophageal ganglion of each side with the otocysts. The latter are formed by involution of the ectoderm of the foot, and the pedal ganglion is formed by delamination from the ectoderm at the sides of the foot.

Urosalpinx cinerea.

The breeding habits of Urosalpinx have been fully described by Professor Brooks.[3] The segmentation is almost identical with that described by Professor Brooks[4] for the oyster, and closely resembles the segmentation of Nassa, as described by Bobretzky.[5] The chief difference between the segmentation in Urosalpinx and Crepidula consists in the fact that while the four macromeres of Crepidula are equal in size, the four macromeres of Urosalpinx are very unequal, one being very much larger than the other three. Two furrows appear simultaneously and seem to divide the ovum into one large sphere and two smaller ones. Really, however, one of the smaller spheres is not completely separated from the larger one, and soon after fuses with it. This smaller sphere is merely a constricted portion of the larger sphere and contains the nucleus. Thus it is seen that of the two furrows mentioned, but one is a true cleavage furrow and it divides the egg into a larger and a smaller moiety. At the next stage the smaller moiety divides into two equal parts, and at the same time two protuberances, each containing a nucleus, are pushed out from the larger moiety. One of these

[3] Preliminary observations on the development of the Marine Prosobranchs. Studies from the Biological Laboratory, J. H. U., Vol. 1.

[4] The Embryology of the Oyster. Studies from the Biological Laboratory, J. H. U., Vol. 1.

[5] N. Bobretzky. Studien über die Embryonale Entwicklung der Gasteropoden. Archiv. f. Mik. Anat., Bd. 13.

IV

V

VI

[illegible] of [illegible] Cryptobran-
[illegible]; [illegible] the [illegible] of
C. [illegible] that [illegible]
[illegible] that of C. [illegible];
and [illegible] the [illegible]
[illegible] and [illegible] more [illegible] than
the other [illegible] work. [illegible]
[illegible] and [illegible]
[illegible] think-
ing to [illegible] and with that
of Cryptobranchus [illegible]
[illegible] and [illegible]. Owing
to the great difficulty in cutting sections of
the [illegible]
[illegible] beyond the [illegible]
of the [illegible] results. [illegible] that [illegible]
that the [illegible] the [illegible]
[illegible]
[illegible]

transformed into a fluid extract by ordinary [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
as hard as a piece of wood.

C[illegible] [illegible]

C[illegible] [illegible], the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] attached to the [illegible] [illegible] another; the first is [illegible] and almost [illegible] the [illegible] is usually attached to [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] is often attached to flax and [illegible] [illegible] [illegible] same [illegible] [illegible] [illegible] the [illegible] of Linum. C[illegible] is [illegible] [illegible] [illegible] flatter than the other forms and is [illegible] [illegible] in color, it [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Epifagus [illegible].

[illegible] of the [illegible] pores. [illegible]

[illegible] partly [illegible]

[illegible] these [illegible] the eye [illegible]

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[illegible] the cause of the

[illegible] of the [illegible]

plain. [illegible]

[illegible] the eye [illegible]

[illegible]

[illegible]

that [illegible]

[illegible] It seems [illegible]

more probable that the [illegible]

[illegible]

[illegible] of the [illegible] the eggs, [illegible]

[illegible]

the experiment of keeping the eggs [illegible]

[illegible] changing the water twice

[illegible] others were placed in [illegible]

[illegible]

were placed [illegible] the [illegible]

[illegible] covered up with [illegible]

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most successful [illegible] was to [illegible]

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[illegible] through

[illegible]

[illegible]

[illegible] that the [illegible]

[illegible] the [illegible]

[illegible] were perfectly [illegible]

[illegible]

of Crepidula [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] direction. The [illegible] [illegible] [illegible] [illegible] on the [illegible] [illegible] [illegible] [illegible] and [illegible] [illegible] they [illegible] [illegible] [illegible] themselves [illegible] [illegible] [illegible] [illegible] of the [illegible] of the [illegible]. [illegible] Crepidula [illegible] [illegible] [illegible] [illegible] from the surface to which they are attached they [illegible] [illegible] [illegible] [illegible] to [illegible] attach themselves.

Method.

The best results were obtained by keeping the eggs [illegible] [illegible] in Perenyi's Fluid, the only [illegible] to the [illegible] [illegible] [illegible] of Kleinenberg [illegible] of the [illegible], [illegible] Fluid, Kleinenberg's Picro-sulfuric Fluid

results. After dipping the specimen [illegible]
of alcohol. As a result of many experiments
I found the best method of [illegible]
[illegible]
[illegible] the [illegible]
[illegible]
[illegible]
(Canada balsam) [illegible]
[illegible]
of Cedar oil [illegible]
the cover glass [illegible]
(B) [illegible] following the [illegible]
[illegible] X [illegible] the [illegible]
[illegible] times [illegible]
[illegible] for [illegible]
[illegible] the [illegible] being [illegible]
[illegible] the [illegible]
and then after [illegible]
[illegible]

II. [illegible]

From the Beginning of Cleavage [illegible]

Closure of the Blastopore.

The unsegmented eggs measured .23 mm in diameter. [illegible] [illegible] [illegible] and [illegible] and in the initial stage [illegible]. First the egg was differentiated into a protoplasmic [illegible] pole and a yolk-containing vegetative pole. The [illegible] then [illegible] [illegible] the surface [illegible] egg at the formative pole.

Two polar bodies are extruded, they [illegible] clear and vesicular and each contains a small nucleolus-like [illegible] [illegible]. The [illegible] on the [illegible] formed [illegible] [illegible] through the body [illegible]. Both polar bodies remain attached exactly at the centre of the formative [illegible] until after the [illegible] [illegible]

[illegible]

[illegible]

of [illegible]

[illegible] which can be seen in the [illegible]

[illegible] which have been drawn in, with the nutritive

fluid surrounding the egg.

<u>First and second furrows.</u> The plane of [illegible]

[illegible]

[illegible] and in many other vertebrates.

The first furrow appears at the formative pole, Fig. 2, and divides the egg into two equal halves, Figs. 3 & 4. The second furrow is at right angles to the first; it appears at the center of the formative area and divides the two spheres [illegible] and [illegible] [illegible] of the first two spheres is usually divided a few minutes before the other, as shown in Figs. 6 and 7. From the earliest appearance of the

[illegible]

obtuse at the center, two are acute. Thus in Figs. 5 and 6, A and B are acute, B and C obtuse. [illegible] [illegible] to distinguish the first [illegible] it is easy to see that the furrow which separates the convolutions A and C from B and K is the [illegible] C and B from C and K is the second since it is not yet [illegible]. If however we look at Figs. 5 and 6 with the first furrow in the line of vision we will observe that the convolutions [illegible] form an obtuse at its center, while if the second furrow be in the line of vision the [illegible] right of the furrow and farthest from the [illegible]

nearer the observer. Thus if we look at Figs. 5 and 6 until
[illegible]
[illegible]
in that time the observer, B, is at the [illegible] while [illegible]
one nearest the pole the furrow in the line of vision will
still be the first one and the [illegible] to the right of the
furrow and in that time the observer C will also be [illegible]
[illegible]. While therefore it is easy to distinguish the
first furrow from the second, we cannot yet distinguish
one end of either furrow from the other end. Of course
in Figs. 5 and 6 it is very easy to distinguish the
first furrow from the second by another method
than the one just mentioned since the second
furrow is not yet complete, but in all the following
[illegible]
is impossible to tell the first furrow from the second
except by the positions of the nuclei, and of these
[illegible]. Both Figs. 5 and 6 are seen from the
vegetative pole and the relations [illegible] between

the first and second furrows, and the obtuse and acute macromeres [illegible] been only when the eggs [illegible] the formation prev-iously the positions would be reversed it the egg were seen from the vegetative pole. [illegible] furrow in the line of vision were the first one the macromere to the right of this furrow and farthest from the observer would be acute at its center, it would be obtuse at its center if the first one in the line of vision were the second.

Segmentation Cavity. At first there is [illegible] cavity between the four macromeres; it is [illegible] at the formation [illegible] at the vegetative [illegible] [illegible] soon after the completion of the second furrow the macromeres crowd together obliterating [illegible]
[illegible]

[illegible] the [illegible] [illegible] called the "cross furrow" [illegible]

[illegible] the centre [illegible] each other [illegible] by the [illegible] length of the cross [illegible]

cross furrow [illegible] transverse to the [illegible] of the [illegible]

[illegible] between the first [illegible]

[illegible] furrow [illegible] the first [illegible] the first furrow [illegible] to the left, [illegible] the second furrow to the right. [illegible]

The examination of [illegible] [illegible] had [illegible] [illegible] has shown that the [illegible] of the [illegible] of the [illegible] to the first and second cleavage planes [illegible] [illegible] and that the first [illegible] furrow [illegible] [illegible] to the [illegible] [illegible]. After a [illegible] of [illegible] [illegible] has been formed [illegible] [illegible] furrows that [illegible] [illegible].

[illegible] formation side of the [illegible] [illegible] the [illegible] [illegible] angles to the [illegible] furrow [illegible] the [illegible] side. Two [illegible] furrows [illegible] opposite sides of the egg and [illegible] at right angles to each other is a [illegible] [illegible] of the [illegible] stage in the eggs of [illegible] [illegible] [illegible], and [illegible] [illegible] [illegible]

[illegible]

to determine the [illegible] on the [illegible]
though I think that it is [illegible]
[illegible] For purposes [illegible]
[illegible]
[illegible] of the [illegible]

[illegible]
[illegible] of the opposite [illegible] the [illegible]
[illegible]
[illegible]
[illegible] at a glance.

The [illegible] have been pointed [illegible]
[illegible]
[illegible] the [illegible] of argument [illegible]
[illegible]

it becomes [illegible] easy to [illegible] the [illegible]
[illegible] and [illegible] the [illegible] the [illegible]
[illegible] furrows. [illegible]
stage, see Fig. 35 [illegible] the [illegible]
[illegible] of the [illegible]
[illegible] that the [illegible]
[illegible] and the [illegible]
[illegible] and that the first cleavage
[illegible] the [illegible] of the
[illegible] and therefore [illegible] the [illegible]
[illegible] right and left [illegible]
the second furrow [illegible] with the trans-
verse axis of the [illegible] and [illegible]
the first [illegible] anterior [illegible]
[illegible] It will be seen
that [illegible] the figures the first furrow [illegible]
[illegible]
[illegible] the anterior-posterior axis [illegible]
[illegible] the [illegible] first [illegible]

[illegible] the first[illegible]
until the stage with twenty four [illegible]
[illegible], Fig. 26.

The [illegible] of the
[illegible] of the [illegible] the
[illegible] of the [illegible] of the [illegible]
[illegible] before [illegible] definite [illegible]
[illegible] on the [illegible]
Until after the formation of the [illegible] first [illegible]
[illegible] from the [illegible]
the [illegible] to the [illegible] of the [illegible]
[illegible]. Oh [illegible] the
[illegible] of the [illegible]
[illegible] to the [illegible]
the [illegible] changed.

The third [illegible] the
[illegible]
[illegible] 1. from the [illegible]
[illegible]. [illegible] the

surface of the four prominences already [illegible] corresponding to the [illegible] of the first [illegible] [illegible]. The inner ends of the fissures are turned toward the outer ends, as is shown in section Fig 65. The fissures do not divide equally [illegible] [illegible] giving to the [illegible] [illegible] different [illegible] of the [illegible] [illegible] each fissure lies in the median line of each prominence so that the fissures lie in the radii of the [illegible], the [illegible] the first and second fissures. Soon after the [illegible] of the [illegible] the furrow separating the prominences from the [illegible] becomes more and more distinct [illegible] the prominences begin to [illegible] in the [illegible] formed by the [illegible] of [illegible]. Fig 10 [illegible] [illegible] continues until as shown in Fig 11 the prominences lie in the furrows between the

manœuvres and alternate with them in position

<u>The fourth manner.</u> When the first four manœuvres have taken a position, alternating with the manœuvres, the manner of the latter [illegible] [illegible] in the preceding changes the [illegible] of the [illegible] [illegible] tial to the ear. And again unlike the [illegible] [illegible] the [illegible] [illegible] the [illegible] and [illegible] finally while the larger [illegible] goes to the [illegible] and [illegible] the [illegible] of the fi[illegible] [illegible] the [illegible] of the [illegible] generation of [illegible] [illegible] of the [illegible] the first of the following the first four manœuvres and at the end.

of the furrows separating them. When the germ

[illegible]

formed, Fig. 12, and before the furrows which

[illegible]

recognized, these granules move in a direction

opposite to that followed by the threads of

which until they meet the [illegible] in

the centre of the egg until the [illegible] of the

[illegible] spindle take a position [illegible]

the [illegible]. The furrows separating the

[illegible] at [illegible], 2, then

[illegible]

[illegible] between the [illegible]

the first two [illegible] 1, turn back to their

[illegible] position on the [illegible]. Fig. 13. From

this position they do not again move

during the [illegible] segmentation.

[illegible]

[illegible]: it divides each of the first four

[illegible] Fig. 14, I, and [illegible] the peripheral cavity, Lx. The [illegible] [illegible] [illegible] around the [illegible] peripheral [illegible] being [illegible] boundaries of the peripheral cavities, Lo, [illegible] during the [illegible] of the [illegible] to the [illegible] stick [illegible] take position in the [illegible] of the egg.

The sixth furrow is vertical. See Fig. 15. Two of the [illegible] of the micromeres are in process of division, one has divided, and the other is preparing for division. The [illegible] of the spindles are at right angles to the [illegible]. Here also the division is [illegible] [illegible] amount of [illegible] going to [illegible]

* I use this term as employed by Haeckel to sign[illegible] [illegible]

end of the spindle then to the other. The
microsomes thus formed, 3, are the fourth [illegible]
[illegible]
[illegible]
are in the direction of the [illegible]
each forming the microsomes of the second
generation, 2, before them until the boundary
[illegible]
lie in the radii, while both these sets of
[illegible]
[illegible]
sixteen microsomes, four large intermediate ones,
1, at the centre, on the periphery of these [illegible]
[illegible]
small radial ones, 1a, while the outer
periphery of the blastoderm is formed by
eight large intermediate microsomes, four [illegible]
[illegible]
[illegible]

Seventh furrow. Very soon after the formation of the fourth set of micromeres the second set, 2, divide in a vertical plane, [illegible] generation Figs 16 and 17, 2a. There is now a slight shifting of the four planes in the limits of the micromeres of each [illegible] dial, while the fourth set, 3, and the fifth, 2a, are shown in Fig. 17. There are now [illegible] do the phenomena of Fig. 18. The first set of micromeres are the only ones which are fully exposed; all the others are partially covered by these. The overlapping began with the formation of the second set of micromeres, [illegible] segmentation.

The eighth furrow is equatorial and [illegible]

it each of the first formed micromeres 1, are again divided into a larger posterior and a smaller anterior [illegible], fig. 17. The [illegible] [illegible] the radii and the new micromeres, 1b, take an interradial position. There are now twenty [illegible] the egg is radially symmetrical. The micromeres 1a, lie in the radii, 1 and 2 lie in the interradii [illegible]

The Mesoblast. From this stage onward the radial symmetry of the egg [illegible] [illegible]. Soon after the last set of micromeres 1b are formed one of the macromeres C [illegible] posterior side and to the left of the median [illegible] [illegible] Fig. 20 and 21 M. and C. By a furrow [illegible] [illegible] think [illegible]

through [illegible] it is [illegible] toward the [illegible].
The [illegible] [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible] to the [illegible]
[illegible] therefore is called the Meridional.
Very soon after it is formed at the sides of a [illegible] plane [illegible] the [illegible] fold. Fig. 21.
[illegible]
that followed by the [illegible] [illegible] [illegible] of the cells Fig. 24 [illegible] to [illegible] at the [illegible]
[illegible]
[illegible] [illegible], the other [illegible] to the left of this

<u>Tenth [illegible].</u> Immediately after the formation of the Meridional there follows a period of [illegible] activity. The [illegible] of the second [illegible] 2, [illegible] [illegible]; the [illegible] of the spindles are nearly parallel with the radii and they cross the [illegible] obliquely [illegible] at the [illegible] [illegible]

The fifth [illegible] of the [illegible]

[illegible] lie in the [illegible] outside, 1' and they form the [illegible] in the [illegible] of a cross Fig. 25, 2', each [illegible] of which [illegible] the [illegible] lines [illegible] of these [illegible] 1'' and 2''. The [illegible] of the [illegible] is exactly [illegible] the centre of the [illegible].

<u>Eleventh</u> <u>furrow.</u> Each of the fourth set of [illegible], 3, [illegible] by [illegible] furrow [illegible] 3 and [illegible] 3a. 15th [illegible] lie in the [illegible].

<u>Twelfth</u> <u>furrow.</u> At the same time each of the fifth set of [illegible], 2a, divides by an equatorial furrow into two parts 2a and 2c both of which lie in the [illegible]. All these

figures are shown in Fig. 22, 23 and 24.

[illegible]

[illegible] [illegible] [illegible] [illegible] lines [illegible] [illegible]
arranged as follows: on the radii 1a, on the [illegible]
radii 1 and 2, on the radii 1b, 2b, 2a, 2c, 3, 3a, [illegible]
[illegible] Octostichs M and M'. In the next stage
Fig. 26 each of the arms of the cross except the
posterior are together [illegible] 1c [illegible] is
[illegible] by the division of 1b.

Smaller [illegible]. At the same stage
Fig. 26 each of the [illegible] [illegible] the [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]

that [illegible] [illegible] [illegible] between
the vertical and the horizontal [illegible]
smaller upper [illegible] 16 A', B', K' and [illegible]
lower [illegible] A, B, K, [illegible] [illegible] filled
with yolk. The smaller [illegible], A', B', K', move
in a direction opposite to the movement of the
hands of a clock until they lie [illegible]

[illegible] of the [illegible] end of the first [illegible] and [illegible] the right and left ends of the second [illegible]. They are thus plainly [illegible] to correspond in [illegible] and position [illegible]

The [illegible]

[illegible] stage and [illegible] divide [illegible] [illegible] the latter. [illegible] the position, at the ends of the first and second [illegible], these smaller [illegible] A' B' and C' [illegible] Maxillulae [illegible] to the [illegible] [illegible] with the [illegible] [illegible].

[illegible]

[illegible] stage, fig. 27, it is seen that the [illegible] the [illegible] [illegible] shifted slightly in the line [illegible] [illegible] and that they [illegible] the [illegible] so that they [illegible] be spoken of as [illegible]

[illegible]

1c, [illegible] of the [illegible] the [illegible]

arm now divides by a furrow parallel with the long axis of the arm into two parts 1c and 1d, Fig. 26; at the same time the terminal cell in the posterior arm 2b divides by a furrow transverse to the long axis of the arm into two parts 2c and 2d. The posterior arm now contains four cells and very soon after the division of its terminal cell its second cell 1b divides in a plane transverse to the long axis of the arm into two parts 1b and 1e, so that the posterior arm now contains five cells arranged in a linear series, Fig. 28; The other arms also contain five cells each and these are not in a linear series, since the middle cell in each arm has divided in a plane parallel with the long axis of the [illegible] longitudinal splitting of the arms, the [illegible] of difference continues until, as seen in Fig. 32, each of these arms is split from

case to [illegible]. The [illegible] [illegible]

[illegible]

[illegible]

[illegible] of the egg, fig. 34.

If we look to fig. 27, then we see that the [illegible] [illegible] divided into a central [illegible]

[illegible]

[illegible]

[illegible]

[illegible] over the macromeres so far that we can not see the peripheral cells without [illegible] the egg.

[illegible]

and it becomes very difficult to trace the further history of the cells unless they [illegible] [illegible] difference that they can be distinguished from the other cells as in the case with the cells of the posterior [illegible].

<u>Mesoblastic Bands.</u> In fig. 7, [illegible] [illegible] the posterior half of the [illegible]

[illegible] to the cells, 1a, [illegible], one on each side, [illegible] to be [illegible] the [illegible] [illegible] in this egg [illegible] cells [illegible] that [illegible] part of a mesenchymatic band though [illegible] the [illegible] cells of such a band. It is only with the greatest difficulty that [illegible] [illegible] make out the [illegible] [illegible] that mesenchymatic bands exist for only a very brief time as continuous bands and that they very soon become broken up into scattered cells. In fig. 31 which was drawn from a very favorable preparation a [illegible] [illegible] cells could be made out [illegible] [illegible]

Fig. 31 toward the Neuroblasts but I could not trace their connection with these cells, although I believe such a connection exists. While the Neuroblasts continue to bud off

cells as they move, round to the ventral side of the egg these cells do not long remain connected with the Mesoblasts. The most anterior parts of the bands,—shown in Figs. 29 and 30,— furnish mesoderm cells which, I think, form the mesoderm which is found at a very early period in the region of the shell gland. As the Mesoblasts move from the dorsal to the ventral side of the ovum [illegible] as their anterior side becomes [illegible]

[illegible]

time the Mesoblasts are but partially [illegible]

[illegible]

parts of the yolk spheres uncovered by ectoderm [illegible] the Mesoblasts become completely covered by ectoderm Fig. 35. From this time [illegible] speak of this uncovered part [illegible] as the Blastopore. Fig. 38 shows a

few mesoderm cells in the lips of the blasto-
pore and in Fig. 40 the mesoderm cells have
extended around to the anterior side of the
[illegible]
the ventral surface.

__The Endoderm.__ Up to the stage repre-
sented by Figs. 39 and 40 there are but seven
[illegible]
endoderm cells — the four original macro-
meres __A, B, C + D__ and the three smaller ones
__A', B', C' + D'__. The smaller cells move around to
the ventral side in the furrows between the
larger ones, i.e. one of these smaller cells __B__
Figs 29 and 33 lies at the anterior end of the
first furrow, one __A'__ lies at the right end (left
if seen from ventral side) of the second furrow
while the other one __D'__ lies at the left end
of the second furrow. As yet there is no
[illegible]

the posterior end of the first furrow. At first the smaller cells are but slightly covered by the ectoderm cells, Figs. 26 and 27, but as the ectoderm moves around to the ventral side farther than they do they gradually become entirely covered by ectoderm Figs. 29, 33 and 35. Partly because these smaller endoderm cells take positions on the periphery of the ventral side and partly because the four larger cells <u>A</u>, <u>B</u>, <u>C</u> and <u>D</u>, flatten in a dorso-ventral direction growing thinner at the center and thicker at the periphery, the ventral side becomes concave and as the ectoderm advances this concavity increases and becomes the archenteron. In the course [illegible] [illegible] tive and finally not shutting off a space between them and the four large

[illegible] and [illegible] the [illegible]

[illegible] is [illegible]

[illegible] Also the [illegible]

At this [illegible]

[illegible] space between the [illegible]

[illegible] close.

The [illegible] [illegible]

[illegible] the [illegible]

arms of the cross particularly 1b and 1c and the [illegible]

[illegible]

increase continuously in size figs. 32 and 34 until they become four or five times as large [illegible]

[illegible]

[illegible]

[illegible] growth characteristic of cells which have entered upon a long resting period. [illegible]

[illegible]

also become much larger than the surround-ing cells Fig. 36; they are regularly arranged [illegible] direction.

[illegible]

[illegible]

[illegible] in figure ... [illegible]

[illegible]

[illegible]

[illegible]

[illegible] nearly the whole of the [illegible]

[illegible] still [illegible]

11 and 12 of the [illegible]. The [illegible]

[illegible] of these [illegible] continuous [illegible]

[illegible] in Figs. [illegible] and [illegible] they [illegible]

[illegible] of the [illegible], while the [illegible]

[illegible] its posterior [illegible] rapidly [illegible]

and more numerous [illegible] preparatory to the

[illegible] of the [illegible]. The [illegible]

was at first [illegible]

[illegible] the [illegible] of the [illegible]

[illegible] which the [illegible] were [illegible]

Figs. 21, 22 and 27 [illegible] posterior [illegible] the [illegible]

[illegible] considerably [illegible]

[illegible] as Figs. 45 and 46 and it was

not until I had found the [illegible]

stages that I was able to determine [illegible]

[illegible] is [illegible] and [illegible]

posterior [illegible] the [illegible] Fig. [illegible].

The skull completely [illegible] of these [illegible] of the posterior arm as [illegible]. The [illegible] at the anterior end of the [illegible] around [illegible] so that they can be partially seen in a ventral view (figs. [illegible] and 43. This skull [illegible] with the [illegible].

[illegible]

ing the [illegible] in [illegible] so that [illegible] the [illegible] is not [illegible] longer than it.

first indication of the [illegible]. The outline of the [illegible] is shown in figs. 41 and 4[illegible] in dark shading. It will be seen that the cavity of the [illegible] is a very short distance [illegible] [illegible] from the cavity [illegible] [illegible] to the posterior end of the [illegible]. This is not [illegible] due to the more rapid closure [illegible] as one would at first be inclined to suppose. In fact the blastopore closes [illegible] the [illegible] that finally it is situated very near the centre of the ventral side figs. 41 and 43. The reason that the archenteron [illegible] position to the blastopore [illegible] [illegible] it has nothing to do [illegible] [illegible] in the fact that the [illegible] A, B and R [illegible] closed [illegible] the anterior and [illegible]

[illegible]

[illegible] p. 43 and 40. [illegible]

[illegible]

[illegible] equivalents [illegible] the corresponding [illegible]. The [illegible]

[illegible] did not become tinted till [illegible] later. The

[illegible]

of the [illegible] that they uplifted [illegible]

the sides of the [illegible] Egypt. It [illegible] to the

[illegible] B.C. [illegible] until 45 [illegible]

[illegible] the [illegible] mixed with

[illegible] and [illegible] probably [illegible]

their [illegible]. From this time until the [illegible]

[illegible]

[illegible] taken the [illegible] in the

[illegible]

[illegible]

Causes of Blood[illegible]. The [illegible]

[illegible] the type of the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The [illegible] thus becomes [illegible] from [illegible]

[illegible], and [illegible] again [illegible]

as the definitive mouth. With the closure of the blastopore we may consider the first period of development accomplished.

[illegible]

There is, at first a small [illegible] ity which is early obliterated.

[illegible]

[illegible]

[illegible] every direction.

After thirty six [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

... Westphal is [illegible]

[illegible]

[illegible]

which are formed on the vertical [illegible] in the direction of a [illegible] [illegible] until they lie in the furrows between the [illegible]meres; when the second generation of [illegible] are formed the first generation is crowded back to their former position [illegible] [illegible] and remain. This [illegible] is

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] [illegible] [illegible] [illegible], [illegible]

[illegible]

[illegible] [illegible] (17) [illegible]

[illegible] of [illegible]. [illegible]

[illegible] [illegible] [illegible] blastomeres

[illegible] [illegible] of [illegible].

[illegible] to 15 [illegible]

ectodermal area instead of the [illegible]

[illegible]

[illegible]

[illegible] 15 [illegible]

[illegible]

[illegible]

[illegible] Infusoria [illegible]

[illegible]

[illegible] Infusoria [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

attached and [illegible]

continues to [illegible] so that [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] the case [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

the tips of the [illegible].

The Endoderm. In Planaria, [illegible]

[illegible] probably in [illegible] [illegible] of [illegible]

[illegible] [illegible] the [illegible] [illegible] is concerned in the

[illegible]

[illegible] to the [illegible]

[illegible] will be [illegible]

enter into the formation of the intestine. [illegible]

[illegible]

[illegible] they [illegible]

the part of the [illegible]. The intestine is

[illegible]

[illegible] the [illegible] of the [illegible]

the [illegible]

III [illegible]

From the Closure of the Blastopore to the Beginning of Larval Life.

External Form. Soon after the closure of the blastopore the embryo becomes [illegible] [illegible] (Fig. No. 147). However [illegible] the [illegible] the [illegible] Figs. 52–54 and following.

With the forward protrusion of [illegible]

[illegible]
the mouth is carried farther and farther
forward until it lies very near the anterior
end [illegible].

The [illegible] of the [illegible]
of the [illegible]
[illegible] the [illegible]
[illegible]
[illegible] toward the ventral side. Thus the
[illegible] is carried [illegible]
[illegible] at this point the [illegible]
the intestine [illegible] toward the [illegible]
[illegible]
[illegible] the left side. [illegible]
has introduced [illegible] greatly [illegible]
[illegible]
the [illegible] posterior to the [illegible]

In well advanced embryos the
[illegible] and the velar folds become

[illegible] constriction [illegible] [illegible]. The latter [illegible] the yolk and [illegible] [illegible] middle [illegible] which lie anterior to this constriction, retain their [illegible].

At the point of constriction there is a large spherical prominence on each side just dorsal to the body; this is the primitive kidney.

On the right side of the embryo just anterior to this constriction a depression appears in the cells [illegible] branchial cavity. Fig 62.

The formation of the gills and of the heart [illegible] is shown in the figures.

The Stomodaeum. [illegible] epithelial [illegible] the [illegible] line [illegible]

Fig. 71 is a transverse section

of the catalogue [illegible] it appears

[illegible]

twisted anteriorly, more evident in [illegible] as is shown in Fig 15 [illegible] compare [illegible] in Figs 49 and 57. This twisting [illegible]

You will see by examining the [illegible]

[illegible]

[illegible] formed [illegible] the exterior [illegible]

[illegible] columns. Explaining the [illegible]

[illegible] to the [illegible] side beside them

[illegible] to each, [illegible]

[illegible] [illegible] the [illegible]

[illegible] [illegible] very [illegible]

[illegible] of the mouth. [illegible]

[illegible] it is seen that [illegible] it

[illegible] is [illegible]

[illegible] the position [illegible]

is better seen [illegible] the [illegible]

[illegible] Figs. 9 and 12, [illegible]

[illegible] the position [illegible]

[illegible] its [illegible] tips [illegible]

[illegible]

[illegible]

its [illegible] and [illegible]

[illegible]

[illegible] the [illegible]

and the [illegible] of the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] 45 [illegible]

[illegible]

[illegible]

[illegible] A, B, C, X [illegible]

[illegible] A', B', C', X' [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] outline. Figs. 77, 51 and 51. The

[illegible] of course has not [illegible] space to the

[illegible] at this [illegible]

[illegible]

At this point the [illegible]

[illegible]

[illegible] the outline. [illegible]

[illegible]

[illegible]

[illegible] to the "[illegible]"

[illegible] in No. 17. [illegible]

[illegible]

[illegible]

[illegible]

Fig. 73 is a [illegible]

[illegible] of the [illegible]

[illegible]

[illegible]

[illegible] precautions, Figs. 15 and 16; [illegible]

[illegible] means the said [illegible]

[illegible]

The positive opening

point

first

of the [illegible]

[illegible]

Fig. [illegible] is a horizontal section [illegible]

[illegible]

[illegible] to the right [illegible] of the [illegible]

[illegible]

inter. [illegible]

[illegible] the [illegible]

[illegible]

[illegible] the same [illegible]

[illegible]

part of the [illegible] end of the [illegible] is [illegible]; [illegible] section [illegible] appears as a [illegible] [illegible] little [illegible] [illegible] the [illegible] [illegible] of [illegible].

Figs. [illegible] are horizontal sections [illegible] [illegible] [illegible]. [illegible] fig. [illegible] the [illegible]

[illegible]

[illegible] figs. 10, 11 [illegible] 12. [illegible] [illegible] the distal end fig. 13 [illegible] [illegible] and [illegible] [illegible] [illegible].

The [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]

Stomach. [illegible] part of the [illegible] [illegible] is bounded by [illegible] [illegible] [illegible] probably [illegible] the [illegible] [illegible] called the "stomach" though it [illegible] [illegible]

structures [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
being [illegible] [illegible] their [illegible] [illegible]
[illegible]
protoplasm of each cell is aggregated [illegible]
the apex which [illegible] the nucleus [illegible] [illegible]
while the rest of the cell is [illegible] [illegible]
with [illegible] [illegible] [illegible] [illegible]
[illegible]
[illegible] around the [illegible] [illegible]
Fig. 75. [illegible] [illegible]
[illegible] [illegible]
[illegible]
[illegible] still [illegible] with [illegible] while farther
back the cells which form the walls of the
stomach cavity remain about the same [illegible]
[illegible] Figs. 76, 77 and 84. The nuclei of
[illegible]
[illegible]

not round but angular and irregular as if they had been pressed out of shape by the yolk spheres. [illegible] the [illegible] cells at the inner end of the [illegible] are [illegible] yolk and on every [illegible] they resemble very much the intestinal cells. These cells extend around the yolk on the right anterior side

[illegible]

and inner part of the yolk is still composed of the large [illegible] yolk cells. Fig. 12.

At first the cavity of the [illegible] is straight. It lies in the median plane of the embryo and throughout its whole course preserves an antero-posterior direction. When the shell gland and the foot attain to

[illegible]

of the embryo is pushed toward the

[illegible]

[illegible] the head surface anteriorly, and [illegible]

it is nearer the vertical [illegible] [illegible].
The course of the [illegible] [illegible] lies in the
median plane [illegible] [illegible] [illegible]
the line connecting the [illegible] [illegible] [illegible]
[illegible] position [illegible] in the [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible],
[illegible]
[illegible] [illegible] [illegible] [illegible] is [illegible]
[illegible] toward the [illegible] side, [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] to the [illegible] [illegible] [illegible]
the [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] with the
[illegible] [illegible] [illegible]. At the [illegible] [illegible]
the [illegible] [illegible] is [illegible] [illegible]
to the right [illegible] [illegible] [illegible] [illegible]
[illegible]
[illegible]

consisting of on the right side of the [illegible]

[illegible] shown in figure 62, [illegible]

[illegible] toward the [illegible]

[illegible] the intestine [illegible]

The Mesoderm. Throughout embryonic life the mesoderm is [illegible] constantly [illegible] [illegible] in the [illegible] [illegible] it is composed [illegible] tissue [illegible] [illegible] surface [illegible] shown in figs. 7, 11, 12 and 14. [illegible] mesoderm cells [illegible] the [illegible] [illegible] and these cells [illegible] from the [illegible] mesenchymatic [illegible] are formed [illegible] [illegible]. The mesoderm cells [illegible] [illegible] in the [illegible] [illegible] become [illegible] of the [illegible] [illegible] unaltered cells [illegible] the mesoderm.

At an early stage the [illegible] [illegible]

the [illegible] separates from the [illegible]

and the cavity thus formed becomes [illegible]

ed in every direction [illegible]

[illegible] appear [illegible]

ectoderm on each side of the [illegible]

[illegible]

In the oldest embryo figured the [illegible]

[illegible]

[illegible] compare the specimens [illegible]

[illegible]ted. At this stage the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

more numerous than when described in the last section and they cover the [illegible] of the [illegible] surface [illegible] to the [illegible]

[illegible]

[illegible] in figs. 45, 47 [illegible] [illegible]

[illegible] their deposit [illegible] to the [illegible]. The [illegible] and the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

their endings.

It will then [illegible] first [illegible]

[illegible]

[illegible] stick [illegible] position [illegible] part of

[illegible] and [illegible] it [illegible] the [illegible]

[illegible]

[illegible] the same [illegible]

[illegible] prominent [illegible]

[illegible] far from the [illegible]

[illegible] side of the [illegible]. Figs. 163 and 164.

[illegible] the [illegible] were studied [illegible] to

[illegible] the [illegible] back [illegible]

the [illegible] would [illegible]

[illegible] at last [illegible] the [illegible]

[illegible] to the [illegible]

[illegible] back [illegible] the [illegible]

[illegible] the [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] by the mouth [illegible]

[illegible] of the [illegible]

[illegible] (…).

[illegible] of the [illegible]

[illegible]

[illegible]

[illegible] they become [illegible]

[illegible]

[illegible]

[illegible] the different [illegible] to [illegible]

[illegible] in the [illegible]

[illegible]

[illegible]

[illegible]

The surface of [illegible]

[illegible] the [illegible] of the [illegible]

[illegible] of the [illegible]

[illegible]

[illegible] the [illegible]

[illegible] the [illegible]

[illegible]

[illegible]

The solution on each side of the [illegible]

[illegible]

[illegible] inward [illegible] of [illegible]

[illegible] taken place [illegible]

[illegible] the surface [illegible]

[illegible] inward [illegible] the [illegible]

the [illegible] on each side [illegible]

[illegible]

on each side from the [illegible]

and that with the highest [illegible], [illegible]

[illegible] combination between the

[illegible] and the [illegible], the [illegible] of the

[illegible] of [illegible]

[illegible] that [illegible]

[illegible]

[illegible] from the [illegible]

[illegible] from the [illegible].

[illegible] the [illegible]

is found in the [illegible] which I

have [illegible] and [illegible] that [illegible]

the [illegible]

[illegible] for [illegible]

[illegible] of the [illegible]

[illegible] the [illegible]

[illegible]

[illegible] that the [illegible]

[illegible] of the [illegible]

graphia.

Conformation.

The skeleton. Blochmann (2) says that in Neritina the smaller [illegible] [illegible] a cap which [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] cap [illegible] with the [illegible] [illegible] [illegible] and [illegible] that the [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the [illegible] side. [illegible] [illegible] [illegible] [illegible] (17) the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]"). [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] and an increasing number [illegible]

[illegible] Sterlitamak. Although it [illegible]

[illegible] the [illegible] of [illegible] be [illegible]

[illegible] [illegible] possible [illegible]

[illegible]

[illegible]

[illegible] that it is [illegible] to the [illegible]

[illegible] of other [illegible].

<u>The [illegible]</u> It is [illegible] known [illegible]

[illegible] is a [illegible] [illegible]

[illegible] [illegible] became [illegible]

as I [illegible] [illegible] the [illegible] to [illegible]

[illegible]

[illegible]

Hatchikyr, [illegible] described it [illegible]

[illegible] together with the [illegible] [illegible]

[illegible] [illegible] Old [illegible]

[illegible] described a [illegible] [illegible]

[illegible]

from the [illegible] at the [illegible] of the [illegible]

[illegible]

[illegible]

IV [illegible]

The [illegible] theorem. [illegible]

fact that there is [illegible] the [illegible]

[illegible]

[illegible] that the distribution of the [illegible]

[illegible]

[illegible] either of these [illegible]

[illegible] to [illegible] of these, the [illegible]

[illegible]

[illegible]) indicating [illegible]

[illegible] to the [illegible]

[illegible]

[illegible]

and Tobias. [illegible] the [illegible]
"[illegible]" [illegible].

[illegible] the [illegible] of the [illegible], the [illegible] the [illegible]

[illegible]

[illegible]

[illegible] a *priori* [illegible] appear that the [illegible] of [illegible] with the [illegible] formation of the center furrow would be an [illegible] [illegible] hundreds of eggs I am convinced that in Crepidula at least it bears a very constant relation to the first and second cleavage furrows. In some cases, e.g. the frog, it seems probable that it bears no constant relation to these cleavages. In Gasteropods [illegible] from the [illegible]

[illegible]

Crepidula; the second genus is still

[illegible] fish and [illegible] the [illegible]

[illegible] the relation of [illegible]

[illegible]

to bear a constant relation to the median furrow [illegible] the [illegible] and at the time are supposed that it bore a constant relation to the [illegible] [illegible] and [illegible].

[illegible] one [illegible] that [illegible] in the [illegible] from the [illegible] [illegible] relation to the first and second furrows this relation may be reversed in a [illegible] species. [illegible] the [illegible] [illegible] [illegible] the median furrow is transverse to the [illegible] of the [illegible]. [illegible] found that the same relation exists in Urosalpinx, though in this case as in other cases it seems to be fairly assured that primarily the relation [illegible] as we found it first in Crepidula.

<u>Relations of the first and second</u>
<u>Cleavages to the [illegible]</u>

Agassiz and Whitman (1) have shown reason

in the case of the frog and newt there is no [illegible] [illegible] [illegible] [illegible] Brooks and [illegible] (23) found it true in [illegible] and Walter [illegible] that the [illegible] [illegible] [illegible] [illegible].

A phenomenon [illegible] [illegible] [illegible] striking cannot be wholly adventitious and without significance.

Whether the early appearance of bilateral symmetry is a phylogenetic or a cenogenetic phenomenon is a question which I shall not [illegible] [illegible] [illegible] [illegible] by Agassiz and Whitman (1) believe that it is phylogenetic, while Metschnikoff (25) and [illegible] (24) maintain that it is [illegible] cenogenetic and they base their argument on the fact that bilateral symmetry [illegible] [illegible] in Ctenophores and other [illegible] [illegible] [illegible] the [illegible] [illegible] development.

[illegible] Oxidation and [illegible]

approximately [illegible] been found [illegible]

[illegible] the first [illegible]

[illegible] and in [illegible]

Neritina there can be little doubt that the [illegible]

midway between the first and second furrows and that both the latter cut it obliquely.

In [illegible] the relation of the first and second furrows to the median plane [illegible] precisely, but here it seems probable that the median plane formerly coincided with the first cleavage and owing to the great accumulation of yolk in one macro- [illegible] have been shifted to one side [illegible]

<u>Cleavage in Urosalpinx.</u> Since the [illegible] to be a type different from that of [illegible], Crepidula, etc. [illegible]

[illegible]

[illegible]

that of the two furrows mentioned above [illegible]

[illegible]

and it divides the egg into a large and a smaller moiety, [illegible] to be an equatorial furrow [illegible] more than a constriction [illegible] during the first division and [illegible] immediately after it.

At the next stage the smaller of the two spheres produced by the first division divides by a vertical cleavage at right angles to the first, [illegible]

[illegible]

[illegible]

[illegible]

[illegible] the [illegible]

the [illegible] smaller ones, the other feet [illegible]

[illegible] articulated portions of the [illegible]

[illegible] and after the [illegible]

[illegible]

[illegible] to the [illegible]

[illegible] of Cephalopoda [illegible]

[illegible], and what makes

[illegible] still more striking is the

[illegible] that [illegible] of the [illegible]

is completed before the other [illegible]

[illegible]

division [illegible] the larger [illegible]

in Cephalopoda, [illegible] and those other

[illegible] one of the first to [illegible]

[illegible] those the [illegible]

probable that the [illegible]

From the four cell stage [illegible]

(5) [illegible]

[illegible]

[illegible].

The [illegible]

[illegible]

[illegible] to the great difficulty in cutting [illegible].

[illegible]

[illegible] of 45° and the males [illegible] this
[illegible] is a true rose [illegible] being transverse
[illegible] the long axis of the [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] than [illegible] the other [illegible] is [illegible]
[illegible] most fundamental one, [illegible]
[illegible] that it [illegible] [illegible]

[illegible]
has been so distributed as to exist under-
[illegible]

It resembles them [illegible] that in
[illegible]
[illegible]
the ovaries not that ovary is the greater
accumulation of egg in one sphere than
the other three the resultant plane
has been shifted until it [illegible] the
[illegible]
between the first and second cleavage
planes. A similar statement would
apparently apply to [illegible] and it is
probable that in the case of [illegible]
and Nereis in which the [illegible]
so nearly equal [illegible]
[illegible] than the other [illegible]
[illegible] the first, [illegible]

to the four varieties of tissue recorded by
[illegible]
shown: Brooks has shown that in the
[illegible] the somatic tissue cells in the
"stolon" and "zooid" stage were
completely separated from the large genera.
I have found the same thing to be true
of [illegible]
4), [illegible] that all the [illegible] of [illegible]

[illegible] appear at both these stages [illegible] [illegible] taken [illegible] of the [illegible] of the [illegible] [illegible] regards the [illegible] the [illegible] of the [illegible], [illegible]

Agassiz and [illegible] (1) [illegible] that this conclusion cannot be accepted and that the first [illegible] [illegible] of the [illegible] of the [illegible] which are found [illegible]. [illegible] therefore, it is [illegible] that the

[illegible]

[illegible]

[illegible]

the [illegible]. It may [illegible]

[illegible]

with the larger one by a narrow neck. If this [illegible] can be explained by a principle of very general application, viz. that before and during nuclear division the more plastic plasma in part of the egg containing the nutritive particles is greater in extent above the level of the yolk containing portion. In that case these phenomena would not represent stages either in the loss or acquisition of a food sack as Brooks (?) has supposed.

Relation of the Axis of the Ovum to the Axes of the Embryo.

As is very well known the formative and vegetative poles of the ovum correspond [illegible] and the line connecting these two poles is the axis of the ovum. The relation of this

eyes to the upper or inner surface of [illegible] is differ[illegible] in different animals.

[illegible]

[illegible] posterior end the [illegible]

[illegible]

[illegible]

directed [illegible] in swimming.

[illegible]

[illegible] the [illegible] by the [illegible] of these eyes are most generally changed.

Among the Turbellaria the [illegible] of the

[illegible]

of the [illegible] the [illegible]

[illegible] the [illegible] side. The [illegible]

[illegible]

in the [illegible] (Rhabdocoela). In these [illegible]

[illegible] the [illegible] is generally [illegible]

elongated [illegible]

[illegible]

nervous system arises along the fused lips of the blastopore or the gastrula papille. In Amphioxus and the Ascidians however the blastopore is [illegible] arises in Ascidians at least so, as in Annelids, [illegible] is formed in [illegible] blastopore [illegible] side in Annelids and Molluscs, and the [illegible] the dorsal side in Ascidians and Amphioxus [illegible], in the same way.

A very great difficulty [illegible] lurks in the [illegible] of a comparison of the [illegible] of Annelids and Molluscs with those of Amphioxus and Ascidians in the [illegible]

are extended and where the real pene-
tration with difference drawn [illegible] the [illegible]
[illegible]
[illegible]
[illegible] that from the
[illegible] appearance of polarity in the
[illegible] and the [illegible] are
[illegible] the [illegible]
[illegible]

Let us now consider some specifying [illegible] of the axes [illegible] to the [illegible] of the [illegible] on the [illegible]:

[illegible] we [illegible] that the [illegible] axis (axis of [illegible]) is perpendicular to the [illegible] axis (antero-poste-rior axis [illegible]) and [illegible]
[illegible]

[illegible] moved to the anterior end.

[illegible] other features the relation of the axis of the ovum to the embryonic axis has been investigated, the results [illegible] [illegible] mentioned [illegible] [illegible]

[illegible] (5) [illegible]

[illegible] anterior end [illegible]

[illegible] the [illegible]

[illegible] [illegible] the [illegible] [illegible]

[illegible]ment.

Balfour (Comp. Emb. II p. 374) on the other hand said that "the conversion of such a radiate form into the bilateral took place not by the elongation of the oral surface and the formation of an axis there but by the unequal elongation of the oral face + + + while the aboral surface became the dorsal surface." This [illegible] was elaborated by Balfour and [illegible] by Sedgwick. Both supposed the original nervous system of actinozoids, [illegible] nerves and [illegible] to [illegible] [illegible]

Allen proposing this theory Balfour says (Comp. Emb. Vol II p. 377) "The position of the ganglion in Pilidium and of the supra-oesophageal ganglion in Actinotrocha suggests a different view of the origin of the supra-oesophageal

[illegible]

pite in the system, shift their position so that they come to lie at the [illegible] end [illegible] [illegible] [illegible] and from these [illegible] the [illegible] simplified.

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[illegible]

[illegible]

[illegible]

[illegible] [illegible]

der [illegible] [illegible]

[illegible] R[illegible] [illegible] die Bakterien [illegible]

[illegible] d. [illegible]

Bact. Centralbl. [illegible], Bd. [illegible], Ste. [illegible]

21. [illegible] [illegible]

die [illegible] [illegible]

[illegible]

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VI. [illegible]

[illegible]

a power of about 25 diameters.

[illegible]

[illegible]

1a = 1st set of micronuclei formed in division of 1.
1b = 2nd set of micronuclei formed in division of 1.

1c = 1st set of micromeres formed by division of 1b.

1d = 1st set of micromeres formed by division of 1c

1e = 1st set of micromeres formed by division of 1e

[illegible] = 3rd set of micromeres formed by division of 1.

2a = 1st set of micromeres formed by division of 2.

2b = 2nd set of micromeres formed by division of 2

2c = 1st set of micromeres formed by division of 2a.

2d = terminal cells of [illegible] formed by division of [illegible]

2e = 3rd set of micromeres formed by division of 2.

[illegible]

Figures.

Fig. 1 = Unsegmented egg, side view.

Fig. 2 = Beginning of 1st cleavage, side view.

Fig. 3 = [illegible]

Fig. 4 = 1st cleavage completed, seen from animal pole.

Fig. 5 = Beginning of 2nd cleavage, seen from animal pole.

Fig. 6 = Half of 2nd cleavage completed, seen from animal pole.

Fig. 7 = 2nd cleavage completed, seen from animal pole.

Fig. 8 = Posterior portion of the [illegible]

[illegible] meeting. The [illegible] of the [illegible] [illegible] is division. The [illegible] [illegible] from both [illegible] divided.

[illegible] The [illegible] are dividing, the [illegible] [illegible] [illegible].

Fig. 11. The [illegible] of [illegible] [illegible] 1 [illegible] [illegible] [illegible] [illegible] the [illegible] [illegible] in the [illegible] of [illegible].

Fig. 11. = [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible]. The [illegible] 2 [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. The [illegible] [illegible] with the [illegible]. The [illegible] [illegible] of the [illegible] of the [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible], 2 the [illegible] [illegible] the [illegible] of [illegible] [illegible] toward the [illegible].

[illegible] The [illegible] [illegible] 3 [illegible]

take positions alternating with the first 1

Fig. 14 Formation of 3rd set of [illegible] [illegible] [illegible]

[illegible]

Fig. [illegible] [illegible]

[illegible]

Fig. [illegible] [illegible] of [illegible] [illegible] 2a

[illegible] 3rd set 2

Fig. 17 Stage with [illegible], [illegible]

[illegible] the [illegible] of the [illegible]

figure.

Fig. 18 = Same stage as Fig. 17, [illegible]

[illegible] [illegible] of [illegible]

[illegible]

Stage [illegible] prominence [illegible]

[illegible] _vii_ which [illegible]

[illegible] of the [illegible]

= [illegible]

[illegible] position of the [illegible]

[illegible] to the [illegible] _C_.

[illegible] the same stage [illegible]

[illegible] in Fig. [illegible] but shown [illegible]

[illegible]

_z_ are [illegible] a second line [illegible]

the 7th at _2 b_, and the 4th at _6_, [illegible]

[illegible] to the [illegible] at _3a_, the [illegible] at _2c_ is [illegible]

[illegible]

[illegible]

[illegible] with the [illegible] A, B & C [illegible] each [illegible].

[illegible]

[illegible] C while the position [illegible]

remaining unchanged. The [illegible] A, B & C, are [illegible] the [illegible]

[illegible] as A', B' & C', which mark the position

of the [illegible]

[illegible]

Fig. [illegible] [illegible]

[illegible]

[illegible] and the [illegible] are [illegible]

[illegible] plane [illegible] the [illegible] of the

[illegible]. The [illegible] in the [illegible]

is dividing [illegible] the [illegible] of the [illegible]. The

[illegible] C [illegible]

[illegible]

[illegible]

[illegible], [illegible] the [illegible] the

[illegible] ...

Fig. 21. – The [illegible] the cell 1c in the anterior [illegible] the [illegible] has divided giving rise to 1d. The terminal cell 2d in the posterior [illegible] has divided giving rise to 2c. The [illegible] 1 [illegible] divided giving rise to 1f. [illegible] the anterior side in the [illegible] band [illegible] beneath the ectoderm on each side of the posterior [illegible].

Fig. 21. – Same [illegible] from the ventral side [illegible]

[illegible]

Fig. [illegible] [illegible]

Fig. [illegible] [illegible] mesoblastic band.

Fig. 22. – The [illegible] the right and left [illegible] of the [illegible] [illegible] [illegible]

Fig. [illegible] Ventral view of [illegible] egg, [illegible]
ing [illegible] from the [illegible]. The [illegible]
[illegible] and [illegible] [illegible]

Fig. 4. – The [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible]

Fig. [illegible] [illegible] [illegible]. The [illegible]
[illegible] [illegible] the [illegible]. The smaller
[illegible] cells [illegible], [illegible] and [illegible] at a higher
level than the larger ones [illegible], [illegible] [illegible]

Fig. 32. – [illegible] [illegible]
[illegible]

[illegible] little. The [illegible]

Fig. 3[illegible]. Ventral view of [illegible]
[illegible] [illegible]

Fig. 3[illegible]. – The [illegible] [illegible]
[illegible] [illegible] [illegible]
[illegible] [illegible]. A [illegible]

cell C' has been formed by the division of C and [illegible] a position between C and C'. [illegible] of the [illegible].

Fig. 40 - [illegible] and the [illegible] [illegible].

Fig. 41 - Portion [illegible] of the [illegible] [illegible].

Fig. 42. The larger [illegible] of [illegible] ([illegible]) [illegible] of the [illegible] [illegible] attached [illegible] [illegible].

Fig. 43 Vertical [illegible] of [illegible]. The [illegible] with [illegible] at the [illegible] [illegible] [illegible] [illegible].

A single row of [illegible] cells crosses the ventral surface anterior to the [illegible] and [illegible] of these [illegible] with the [illegible] [illegible].

Fig. 44. Side view of same embryo. The large [illegible] cells extend [illegible] the [illegible]. The [illegible] [illegible] dorsally.
[illegible] the [illegible] cells.

Fig. 45. Anterior view [illegible]. The [illegible] [illegible] can be seen at the
cells
[illegible]
[illegible]
the [illegible] cells.

Fig. 46. [illegible] is [illegible]. The [illegible] [illegible] [illegible]
[illegible]
[illegible] in the [illegible] of the [illegible]
[illegible]

Fig. [illegible] [illegible]
[illegible]

is a median protuberance, [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Same embryo seen from left side. [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

cells, the primitive kidney. The [illegible] gland has enlarged. The [illegible] between the yolk cells is seen [illegible] beneath the [illegible] cells. The oesophagus opens into the anterior end of the [illegible] brain.

Fig. 52.– The [illegible] have grown more prominent, the posterior branch crossing the [illegible] and the anterior branch turns forward around the side. The [illegible] forward [illegible] than [illegible] right.

Fig. 53.– [illegible]. The anterior branches of the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Fig. 71. – Transverse section of [illegible] germinating [illegible]

[illegible]

Fig. 72. – Longitudinal section of [illegible] in which the [illegible]

Fig. 73. – Horizontal longitudinal section [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Fig. 76. – Longitudinal section [illegible]

[illegible]

the point where the [illegible]

[illegible]

[illegible]

[illegible]

Fig. [illegible] – Horizontal longitudinal section [illegible]

but taken a little further toward the [illegible].

Fig. 15 = Horizontal longitudinal section through the foot and anal prominence.

[illegible]

Vita

[illegible]

[illegible] years I was a student in the Ohio Wesleyan University, from which institution I received the degree of S.B. in 1883 and the degree of A.B. in 1886. From [illegible] 1885 [illegible] three years [illegible]

[illegible]

[illegible] I [illegible] Johns Hopkins University, studying [illegible] subjects [illegible] Morphology, [illegible] [illegible] Physiology, and [illegible] Geology.

[illegible] fortune [illegible] Prof. Brooks, Prof. [illegible], Dr. Howell, Dr. [illegible], [illegible], Dr. [illegible] and Dr. [illegible] [illegible] Prof. [illegible] [illegible] Dr. [illegible]